Creating Time and Responsive Dimensions in Science with Mobile Technology

Abstract

The use of mobile devices such as smartphones in higher education has increased. They are now used extensively to support learning in a variety of fields including medicine and the healthcare sciences and underpin delivery of novel teaching approaches such as the flipped classroom. A review of findings from three studies using this approach in a biomedical sciences programme has shown a positive effect on learning. We discuss how generation of safe cognitive spaces in the classroom and putative changes in the chemistry of the brain may allow this deeper level of learning.

Keywords

Medicine, Healthcare, Science, Biomedical, Flipped, Flipping, Capture, Panopto, Time, Cognitive, Space, Safe, Safety, Brain, Thematic, Psychosocial, Stress.

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Introduction

Mobile learning is now used extensively in higher education (HE) (El-Hussain & Cronje, 2010). The use of this technology most commonly represented by smartphones (Ofcom, 2015) allows approaches such as the flipped classroom or 'flipping' to be facilitated (Bishop & Verleger, 2013). Content is recorded, made available online before class through a mobile device (Bergman & Sams, 2012) leaving face-to-face sessions free for other activities that support learning. The use of the flipped approach has been shown to have a range of positive impacts on students (Witton, 2016; Smith, Brown, Purnell & Martin, 2015).

This chapter will review the findings of studies undertaken in a healthcare science programme that employed flipping. These investigations show that although the technology facilitates delivery it may not cause the changes seen in students *per se*. We hypothesise that it is what we term 'safe cognitive dimensions' that are important for students. These spaces within groups promote a deeper learning approach and perhaps cause fundamental changes at the level of the students' brain chemistry. We aim to show how the use of technology creates time and responsive dimensions in science education; a more receptive approach that reflects how students like to learn. Here we also begin to link the electronic to the physical, something that is yet to be addressed in Mobile learning research.

Literature review - Use of mobile technology for learning in medicine and the healthcare sciences

Mobile technologies have been used in a variety of disciplines within medicine and healthcare science. This section presents a selection of the current literature regarding how mobile technology is being used in these subject areas and provides context for the study presented later.

The medical professional requires a wide variety of knowledge to carry out their everyday tasks. Mobile devices are now increasingly being employed by medical students and physicians in the work place to access information relevant to their role. The technology can provide a form of dynamic scaffolding that is responsive to the learners own developing knowledge and competence (Bullock, Diamond, Webb, Lovatt, Hardyman & Stacey, 2015). Initially, in medical education mobile devices were used to deliver lecture content and textbooks (Woodill & Udell, 2011). Internet audio broadcasts (podcasts) were subsequently introduced as an important way to deliver content (Long & Edwards, 2010). With the increase in availability of connected technology there is an increase in the use of task specific mobile applications or 'Apps' to support learning. Medical education apps are now prolific (Woodill & Udell, 2011). The types of apps range from educational programs such as the Visible body (www.visiblebody.com) to resources such as Daily Rounds for doctors (Sebin, 2015). In their study to investigate how an app could support the practice of newly qualified doctors in the United Kingdom (UK) Bullock *et al*., (2015) established that physicians responded positively to the increased access to up-to-date text books afforded by the app. The important point is that the app was seen to supplement learning and surprisingly also increased the interaction of junior doctors with more senior medical staff. Although the app was providing content it was not a replacement for human interaction; it enhanced participation in the community of practice (Bullock *et al*., 2015).

The use of mobile technology for learning across other healthcare disciplines is similar due to the nature of the factual material to be accessed. However, the use of mobile technologies to facilitate the flipped classroom is one area that has been evaluated widely in this setting (Pierce & Fox, 2012).

The subject area of pharmacy encompasses training to prepare individuals for eventual practice as a registered pharmacist. As with other disciplines students are required to apply their learning in a variety of contexts. This requires a deep approach to learning which cannot be achieved through simple didactic delivery; an active learning strategy is required (Schneider, Munro & Krishnan, 2014). To achieve this Schneider *et al.*, (2014) used a flipped classroom approach which provided more time for students to engage in discussions and problem solving exercises during their lesson. They found that although the different teaching style motivated students to engage there was no subsequent increase in student attainment in summative assessments. The major benefit reported was from the increased interaction with peers enabling peer learning to take place (Schneider *et al*., 2014).

In contrast, Pierce and Fox (2012) who also used flipping for pharmacy education to provide time and space in the classroom for assessing and developing student knowledge, reported an increase in student performance. Similar findings were identified by Missildine, Fountain, Summers, and Gosselin (2013).who evaluated the impact upon exam performance for nurses, comparing flipped classrooms with traditional ones. They identified higher exam scores as well as greater student satisfaction scores for the flipped approach. Others have evaluated the wider impact of flipping on student learning and professional development identifying its role in promoting team working skills essential in the healthcare setting (Clark, 2014).

Biomedical science is a multidisciplinary laboratory based role within the healthcare sciences. In the UK biomedical scientists often work within the National Health Service

(NHS) and support diagnosis of disease in samples taken from patients. This is a demanding subject area where students must relate theory to practice and apply rigorous scientific method in the laboratory. As such the biomedical science classroom faces many of the challenges other medical sciences do, including how to create a deep approach to learning. To achieve this in their classroom Ernst, Harrison & Griffin (2013) created a smartphone app called the Virtual Human Body (VHB). Students engaged with the VHB using a variety of different devices and acknowledged that the app helped them to prepare for their final assessments. They also appreciated the go anywhere, learn at your own pace, anytime nature of the programme and the authors demonstrated that the use of the app enabled a deeper approach to learning in their students (Ernst *et al*., 2013).

Each of the studies presented here have shown that the use of mobile technology in medicine and the healthcare sciences can allow the formation not only of communities of practice but also communities of learning. It supports the creation of space and time within the classroom for interactions to occur beyond that found in the traditional classroom and increases engagement with content. It allows the formation of relationships and gives students the opportunity to interact with tutors at a collaborative level. In summary the use of mobile technology, and the different teaching methods it can afford, leads to a range of valuable changes in students which are not just based upon attainment in exams.

The study outlined in the following section addresses how we have used mobile technologies, their impact upon our approaches to teaching and their impact upon students' perceptions and attitudes to learning within these classrooms.

Methodologies, methods and approaches taken in the studies reviewed

The data used here was taken from three different studies at both undergraduate and post graduate levels on a biomedical science education pathway. The studies were all firmly grounded in a socially constructivist paradigm (Andrews, 2012) where learning is seen as a collaborative event. This reflects the nature of training in healthcare sciences as capability is developed by interaction with a community of practice and as such is a valid epistemological standpoint for the work undertaken. As the researchers involved in the studies are practitioner researchers and part of the academic team on the programmes where the studies took place an action research methodology was also employed (Open University, 2005).

Study one was carried out at post graduate level and involved the use of the flipped classroom only. Students in this study did not use technology in the classroom but did access the flipped content on mobile devices before the session (Smith, Brown, Purnell & Martin, 2015).

Study two built on the findings of study one and also took a flipped approach at post graduate level. However, in this case students were also encouraged to use mobiles in the classroom to review progress using the App Socrative (www.socrative.com) and to use their devices for internet searches during group work. The 'bring your own device' (BYOD) (Sharples, Adams, Ferguson, Gaved, McAndrew, Rienties, Weller & Whitelock, 2014) approach to mobile learning was positively encouraged in these sessions where appropriate. The functioning group ensured that all students had access to any content needed even if they did not have a device of their own (Smith and Khechara, 2016).

The third study was carried out at undergraduate level and used the flipped approach to deliver instructional content to aid in understanding of practical laboratory classes. Mobile devices specifically for use in the laboratory environment were supplied in the form of a tablet device (Smith, O'Gara and Khechara, 2016).

Each of the studies used lecture capture software such as Panopto (www.panopto.com) to record and distribute the flipped content. This software allows the academic to record high definition (HD) video and sound including slide or screen capture as well as feeds from other camera enabled devices such as microscopes. This is all facilitated by the operator on a stand-alone device such as a desktop or laptop computer with a web cam and suitable microphone. Recordings are then delivered to the viewer through an online player accessed via a web link. In all cases perceptions of students were evaluated through the use of semi-structured focus groups. Discourse from these sessions was electronically recorded and transcribed verbatim. For the purposes of this review transcripts from focus groups from the three studies undertaken have been recoded using thematic analysis (Braun & Clarke, 2006) to allow a qualitative comparison of the data in each of the three projects undertaken.

Findings and Reflections

Themes arising from transcribed discourse were identified and a number of different interrelated codes established. These represented aspects of how the activities and use of mobile devices changed students personally, how it modified attitudes to work or modified attitudes towards the subject area.

For the postgraduate students the flipped approach was acknowledged as allowing the creation of extra time in the classroom as highlighted by the excerpt from the first focus group where students acknowledged the benefit of having more time with their tutors:.

> You only have 3-4 hours in a whole week [contact hours per module]. You can use that time to ask questions and do more practical application of what you have learnt rather than just listening to theory. (Focus group 1, PK)

These findings reiterate the work of others who have demonstrated that flipping provides more usable time in the classroom (Pierce and Fox, 2012). It is this perceived extra time that enables a range of approaches to be adopted and so allows for the variety of changes we identified in students. The provision of more ‘class time’ in the postgraduate modules provided students with time to think, reflect and most importantly, to explore. Here we propose the term ‘cognitive time machine’ to express how the flipped class room creates time and space for the active learning strategies to be employed and the development of higher order thought processes that ultimately lead to deep learning strategies in students.

The flipped classroom is underpinned by the initial provision of material to be accessed via mobile devices and in particular the students own. This socio-culturally appropriate use of technology to facilitate teaching and learning directly increased student engagement with the subject area from the start as demonstrated by the comments of one student outlining their approach to accessing the material:

> If I am watching a video on my phone, I am more engaged, as it’s more interesting to see images and figures on my phone it’s like a movie so I’m more engaged (Focus group 1, HS).

The power of the method to promote engagement was seen to occur in spite of a student’s initial perceptions of the subject area and clearly shows the effectiveness of reversed pedagogies. One student clearly articulated this when discussing their thoughts on the flipped classroom:

> This approach awakes your interest even if you are not interested in it. (Focus group 2, CW)

Increased engagement by students resulted in a greater understanding of the subject content and in turn facilitated further engagement. The format and ability to interact with content to learn at their own pace was identified as an advantage: the excerpt below was a typical response from students in all three studies

> The best thing about it is that you can pause and rewind, so if you don't understand something you can go back and look at it again, where as in class you don't feel like you should interrupt. (Focus group 2, LJ)

As the students engage and their understanding increases they see the value of a different approach to lesson structure and learning tasks. Indeed all students from the three studies preferred the flipped delivery and thought the changes bought about in the classroom were positive.

The effects outlined relate to changes in how students engage with information and the teaching approach itself. However, the effect of the cognitive time generated can also be seen as a change in the attitudes of students towards themselves or others. Time in class where a student centric pedagogy prevails and group work can take place, facilitated by an academic allowed relationships to form and grow between peers and between the students and teachers. This is seen as a valuable part of the learning experience as extra direct contact time could be used to explore problems with tutors in greater depth and students felt they received more support. Students commented on how they valued the extra support provided in the flipped classrooms and their perception that this time was of more value to them:

> You feel that you are getting more help and support from staff, from the lecturers; you feel that they are able to give you the support that you need. (Focus group 2, LC)

Growth in relationships in the classroom through group working activities helped to build the confidence of students and further reinforced their ability to form relationships. This made students more comfortable to interact with activities such as presentations. This relationship building was clearly identified by the students in each of the focus groups though was more evident in the two which used mobile devices for in-class activities; these activities appeared to support the relationship building. The impact is evident from the students comment below

> [Classroom activities]… With presentations in the activities of the flipped, you would normally be nervous, but now we have got to know our peers, it’s a lot easier, because we have made a relationship with them through interactive learning, in that sense you feel more confident standing up and presenting.(Focus group 2, LJ)

The use of mobile devices in the laboratory was also seen to increase students’ motivation to interact. Here the flipped approach was adopted differently by students. Although intended to provide pre-class instruction, the majority of students accessed the instructions and demonstrations of techniques provided during the class time as required. This meant they did not have to ask for or wait for extra support from tutors. This further reinforced the emotional changes that we had identified in the previous studies enabled via a flipped approach. One student commented;

> [Flipped laboratory]… I think it gives you the motivation to literally study to put your all into it. (Focus groups 3, PB)

This identifies the positive impact on student attitudes. There was an increased motivation to engage in the topic and the learning activities in the laboratory. Students were able to watch the demonstrations on the tablets on their own or as a group to support their activities and progress through the practical class. A positive effect on the students' level of confidence was seen and it also reinforced their ability to build relationships through this shared experience.

In summary, the changes in attitudes and emotional state of students bought about by the flipped classroom and the active learning approaches used, generated a deeper level of learning. Engagement in the topic content and a greater level of understanding when combined with the relaxed nature of the group, better relationships and motivation may be the driver for this change in cognitive processing. However, we feel that a more fundamental force is at work that underpins everything and affords students the cognitive space in which to change. This is the formation of safe spaces or what we have termed 'safe cognitive dimensions'.

In educational terms a safe space has been defined as: 'An environment in which everyone feels comfortable expressing themselves and participating fully, without fear of attack, ridicule or denial of experience' (Arao and Clemens, 2013 pp. 135-151). Hockings (2011) refers to safe spaces as safe inclusive spaces. She suggests that the HE classroom is often an inhospitable place focusing on delivery rather than dialogue between those in the classroom. This is particularly the case when students are taught in large classrooms where there is little opportunity for relationships to grow. Students rarely speak in these spaces for fear of appearing stupid. The environment has a numbing effect on the mind and promotes non-engagement. However, safe cognitive dimensions for learning can be established by developing relationships with students (Hockings, 2011).

In the studies reviewed the active learning approaches used in the flipped classroom addressed some of the negative factors experienced in the traditional classroom setting and allowed the formation of relationships consequently generating a feeling of safety.

We posit here that a safe cognitive dimension is a mental construct of the students mind and is related to the level of psychosocial stress experienced. Psychosocial stress results from being confronted with perceived social threats that we think we may not have the resources to deal with mentally (Scott, 2016). Prolonged exposure to this type of stress may result in poor performance, disinterest, dejection and memory disturbances (Danielsson, Heimerson, Lundburg, Perski, Stefansson and Åkerstedt 2012). Indeed stress has been shown to impair memory retrieval and is acknowledged to inhibit memory formation and learning particularly in a region of the brain called the hippocampus where memories are processed and stored (Mohapel, Leanza, Kokaia and Lindvall, 2005; Kuhlman, Piel and Wolf, 2005). This in part occurs through the action of a hormone called cortisol that is produced in response to stress (Kalat, 2007; Wolf, 2009). This taken together begins to explain the basis of what we see in the classroom during flipped sessions. A reduction in psychosocial stress experienced by the students in working in a group should lead to a reduction in stress hormone production and consequently allow better memory formation and recall and allow better learning (Clark, Kirschner and Sweller, 2012).

Mobile Technology and the flipped classroom: Concluding reflections

We have seen that mobile technology can be used in a variety of ways within medicine and the healthcare sciences to support learning. However, the introduction of mobile or another kind of technology into the classroom is not a simple panacea that can 'fix' the learning process. Technology is just a tool that without reflection on teaching practice by academics using it may have a negative effect (Carter, Greenberg and Walker, 2016). The use of the flipped classroom shows this particularly as the delivery of recorded didactic content cannot simply be used as a replacement for good teaching practice. Active learning strategies must be employed. This takes time and effort on the part of the academic to implement and facilitate and without this, effectiveness is lessened.

Theories of time and the psychoneurobiological effects of the flipped classroom:

Here we have tried to unite the technological the pedagogical and the biological in an attempt to present a theory of how the flipped approach leads to improved learning. Our results suggest that the use of the flipped classroom when facilitated in our case by mobile devices develops safe cognitive dimensions through the creation of usable time. The method represents a cognitive time machine literally creating time where it was limited before allowing time to think, build relationships, develop understanding and produce a more engaged student. This all reinforces a sense of safety that reduces stress to allow the deeper approach to learning. seen in these sessions.

Further work:

The role of stress and its effect on learning is very controversial (Wolf, 2009). Changes in stress levels in students exposed to traditional or flipped environments could be assessed indirectly through measures such as the UWIST test (Matthews, Jones and Chamberlain, 1990) or directly through the measurement of student salivary cortisol levels. Further work is certainly warranted in this area to determine whether a definite link to the effects of psychosocial stress and learning in the flipped classroom can be made.

Final Conclusions:

In conclusion, we have shown the flipped class room supported by mobile technology has an impact on students, how they learn and perhaps even modify their brains to learn more effectively. As practitioner researchers we continue to change our practice through the use of these pedagogies and as we move into the future of a more rigorous funding structure in UK HE we will continue to use them to create time and responsive dimensions in science.

References

Andrews, T. (2012) What is Social Constructionism? *The Grounded Theory Review. 11* (1) 39-46.

Arao, B & Clemens, K. (2013) From safe space to brave spaces. In Landreman, L. M, *Art of effective facilitation: Reflections from social justice educators* (1st ed., pp. 135-151). Stirling Virginia: Stylus.

Bishop, J. L. & Verleger, M. A (2013) The flipped classroom: A survey of the research. ASEE National conference proceedings, Atlanta, GA.

Braun, V. & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research In Psychology, 3*(2), 77-101.

Bullock, A., Dimond, R., Webb, K., Lovatt, J., Hardyman, W. & Stacey, M. (2015) How a mobile app supports the learning and practice of newly qualified doctors in the UK: an intervention study. BMC Medical Education. 15 (71) 1-6.

Bergman, J & Sams, A. (2012) Flip your classroom. Reach every student in every class every day. Washington DC. International society for technology in education.

Carter, S. P., Greenberg, K. & Walker, M. S. (2016) The impact of computer usage on academic performance: Evidence from a randomised trial at the united states military academy. *School Effectiveness and Inequality Initiative.* 1-30.

Clarke, K. (2014) Flipping Out: A Trend in Radiologic Science Education. Radiologic Technology, 85 (6), 685-687

Clark, R. E., Kirschner, P. A. & Sweller, J. (2012) Putting students on the path to learning.

The case for fully guided instruction. *American Educator*. 6-11.

Crompton, H. (2013). A historical overview of mobile learning: Toward learner-centered education. In Z. L. Berge & L. Y. Muilenburg (Eds.), *Handbook of Mobile Learning* (pp. 3-14). Florence, KY: Routledge.

Danielsson, M., Heimerson, I., Lundburg. U., Perski, A., Stefansson, C and Åkerstedt, T. (2012) Psychosocial stress and health problems. Health in Sweden: The national public health report 2012. Chapter 6. *Scandinavian Journal of Public Health*. *40* (9), 121-134.

El-Hussain, M. O. M &Cronje, J. C. (2010) Defining mobile learning in the Higher Education landscape. *Educational Technology and Society*. 13 (3) 12 -21

Ernst, H., Harrison, J. & Griffin, D. (2013) Anywhere, anytime, with any device: scenario-based mobile learning in biomedical sciences. *International Journal of Mobile Learning and Organisation*. *7* (2), 99-111.

Hockings, C. (2011) Hearing Voices, creating spaces: the craft of the 'artisan teacher' in a mass higher education system. *Critical Studies in Education*. *52* (2), 191-205

Kalat, J. W. (2007) Stress and health. In Biological Psychology (376-377) California. CA Thompson Wadsworth.

Kuhlman, S., Piel, M. & Wolf, O. T. (2005) Impaired memory retrieval after psychosocial stress in healthy young men. *The Journal of Neuroscience*. *25* (11) 2977-2977

Long, S. & Edwards, P. (2010) Podcasting: Making waves in millennial education. *Journal For Nurses in Staff Development*, *26* (3), 96-101.

Matthews, G., Jones, D., & Chamberlain, A. (1990). Refining the measurement of mood: The UWIST Mood Adjective Checklist. *British Journal Of Psychology*, *81*(1), 17-42.

Missildine, K., Fountain, R., Summers, L., & Gosselin, K. (2013). Flipping the classroom to improve student performance and satisfaction. *Journal of Nursing Education, 52(10),* 597-599.

Mohapel, P., Leanza, G., Kokaia, M. and Lindvall, O. (2005) Forebrain acetylcholine regulates adult hippocampal neurogenesis and learning. *Neurobiology of aging*. *26*, 939-946

National Careers Service, (n.d.) Job profiles: Biomedical Scientist. Retrieved from https://nationalcareersservice.direct.gov.uk/advice/planning/jobprofiles/Pages/biomedicalscientist.aspx

Ofcom (2015) The Communications Market report. Retrieved from http://stakeholders.ofcom.org.uk/binaries/research/cmr/cmr15/CMR_UK_2015.pdf

Open University (2005) Action research a guide for associate lecturers. *Centre For Outcome Based Education.* Retrieved from http://www.open.ac.uk/cobe/docs/AR-Guide-final.pdf

Pierce, R. & Fox, J. (2012) Instructional design and assessment. Vodcasts and active-learning exercises in a flipped classroom model of a renal pharmacology module. *American journal of Pharmaceutical education*. *76* (10), 1-5.

Schneider, J., Munro, I. & Krishnan, S. (2014) Flipping the classroom for pharmacokinetics. *American Journal of Educational Research. 2* (12) 1225-1229.

Scott, E. (2016) What is psychosocial stress. Received from https://www.verywell.com/what-is-psychosocial-stress-3145133

Sebin, D (2015, May 04) top 10 must have medical apps for medical students and doctors. [Weblog comment] Retrieved from http://www.dailyrounds.org/blog/top-10-must-have-medical-apps-for-medical-students-and-doctors-for-usmle-preparation/

Sharples, M., Adams, A., Ferguson, R., Gaved, M., McAndrew, P., Rienties, B., Weller, M., & Whitelock, D. (2014). *Innovating Pedagogy 2014: Open University Innovation Report 3*. Milton Keynes: The Open University.

Smith, S., Brown, D., Purnell, E. and Martin, J. (2015) ‘Flipping’ the Postgraduate Classroom: supporting the student experience. In: Global Innovation of Teaching and Learning in Higher Education. Transgressing Boundaries. Layne, P. and Lake, P. (Eds) Series: Professional Learning and Development in Schools and Higher Education, Vol. 11 . Springer Publishing International

Smith, S. & Khechara, M. (2016). ‘Technologizing’ the Postgraduate Classroom. In *Edulearn16*. Barcelona: Edulearn.

Smith, S., O'Gara, E., & Khechara, M. (2016). Developing student capability in a biomedical science award – peer supported learning through video. In *Edulearn16*. Barcelona: Edulearn.

Witton, G (2016) The value of capture: Taking an alternative approach to using lecture capture technologies for increased impact on student learning and engagement. *British Journal of Educational Technology*, Early View.

Wolf, O. T. (2009) Stress and memory in humans: Twelve years of progress? *Brain Research*, 1293, 142-154.

Woodill, G. & Udell, C. (2011) Mobile learning in medicine and healthcare: professional education applications. Float mobile Learning. Retrieved from http://info.floatlearning.com/hs-fs/hub/241955/file-285652672-pdf/docs/mobile-health/mobile-learning-medicine-healthcare-professional-education-applications.pdf